

Analyzing Mediating Effects in Social Sciences



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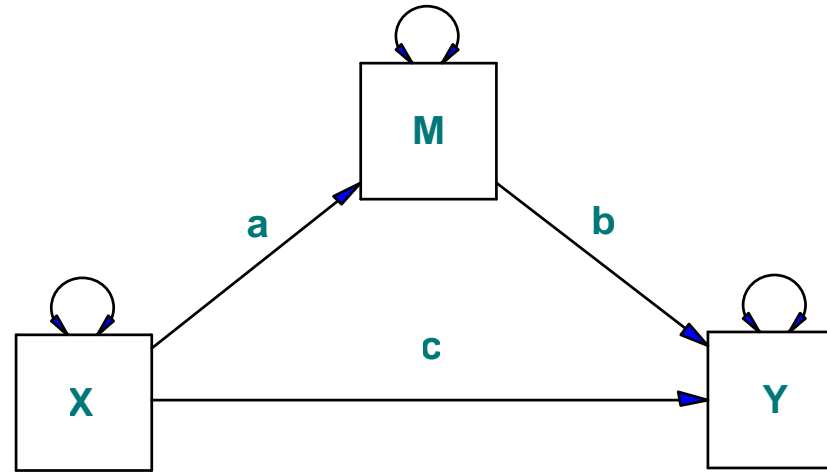


Introduction

- u A mediator is a variable that explains the psychological mechanism between two variables (Baron & Kenny, 1986; James & Brett, 1984)
- u The article by Baron and Kenny (1986) has been cited +7,600 times in ISI citation index
- u This indicates that mediating models are very popular in social sciences



A model with one mediator



- u Two approaches (James, Mulaik, & Brett, 2006):
 - Multiple regression
 - Structural equation modeling (SEM)
- u Types of effects:
 - **Direct effect:** c (easy to test)
 - **Indirect (mediating) effect:** ab (more challenging to test)
 - **Total effect:** direct effect + indirect effect ($ab+c$) (easy to test)



Significance test on the indirect effect

- u Based on the delta method, Sobel (1982) derived the standard error (SE) of the indirect effect:

$$\hat{SE}_{ab} = \sqrt{a^2 \hat{SE}_b^2 + b^2 \hat{SE}_a^2}$$

- u The estimated indirect effect (ab) divided by its SE follows a standard normal distribution:

$$z = \frac{ab}{\hat{SE}_{ab}}$$



Confidence interval (CI)

- u CI is suggested as a better alternative to the significance test (e.g., American Psychological Association, 2001)
- u A 95% Wald CI can be constructed by

$$ab \pm 1.96 \times SE_{ab}^{\wedge}$$



Does the Sobel's test work?

- u MacKinnon et al. (2002) and MacKinnon, Lockwood, and Williams (2004) found that Sobel's method might not be accurate in terms of Type I error and power in small samples.
- u Sobel (1982) himself also stressed that "Since one seldom knows when a sample is large enough, the application of these methods may be inappropriate in particularly small samples" (p. 308).



Other issues surrounding the regression approach

- u Significance tests (and CIs) based on asymptotic *SEs* (e.g., Sobel's method) may not be accurate in small samples
- u It is difficult to generalize the regression approach to other mediating models, e.g., specific mediators, multiple mediators and moderated mediators.



Objectives of this presentation

- u 1. Demonstrate how SEM may be used as an integrated approach to analyzing mediating models
- u 2. Compare Wald confidence interval (CI), likelihood-based CI, and bootstrap CI via computer simulations

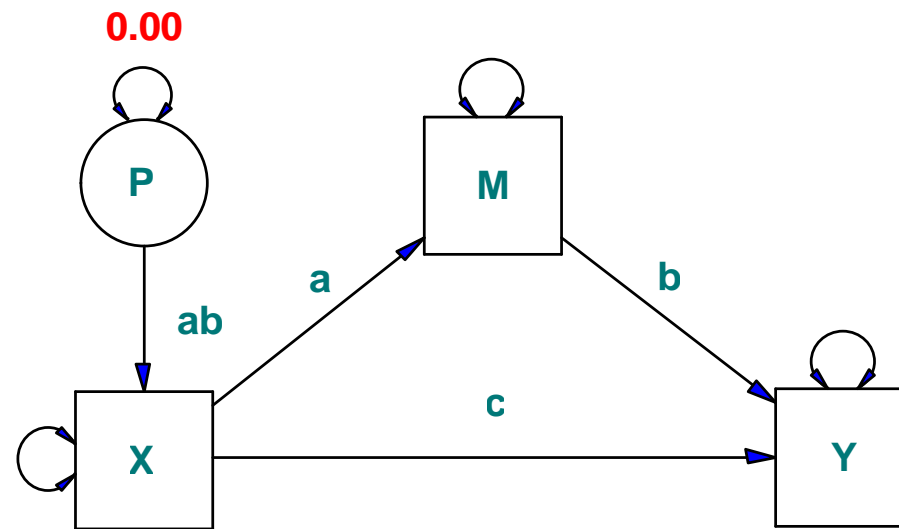


Other types of CIs

- u Likelihood-based CI:
 - Based on the likelihood function
 - Wald CI is an approximation of it
- u Bootstrap CI:
 - Based on resampling the raw data
 - Percentile bootstrap and bias-corrected bootstrap are two common choices
- u Many SEM packages have functions to constructs these CIs.



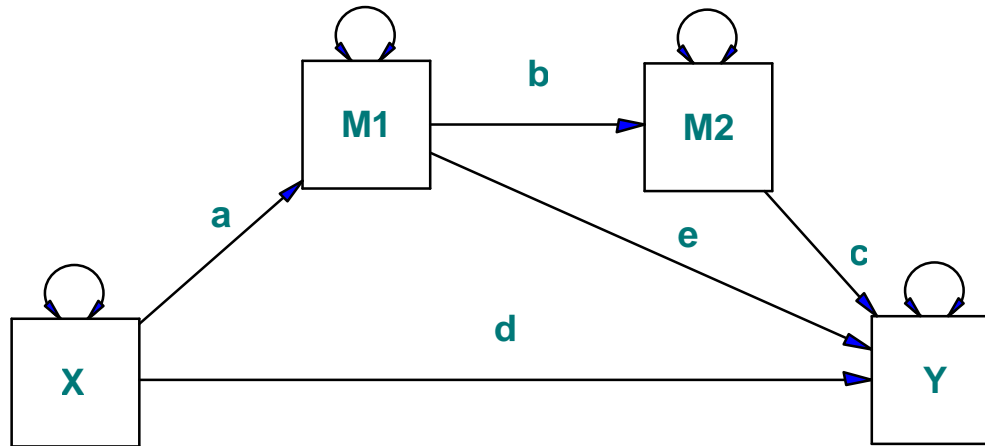
An SEM approach: one mediator



- u We add a phantom variable (Rindskopf, 1984) in the model. The phantom variable does not affect the model fit and the parameter estimates.
- u We fix the **path=ab**
- u Significance test and CI on the path **are** the same for the indirect effect.



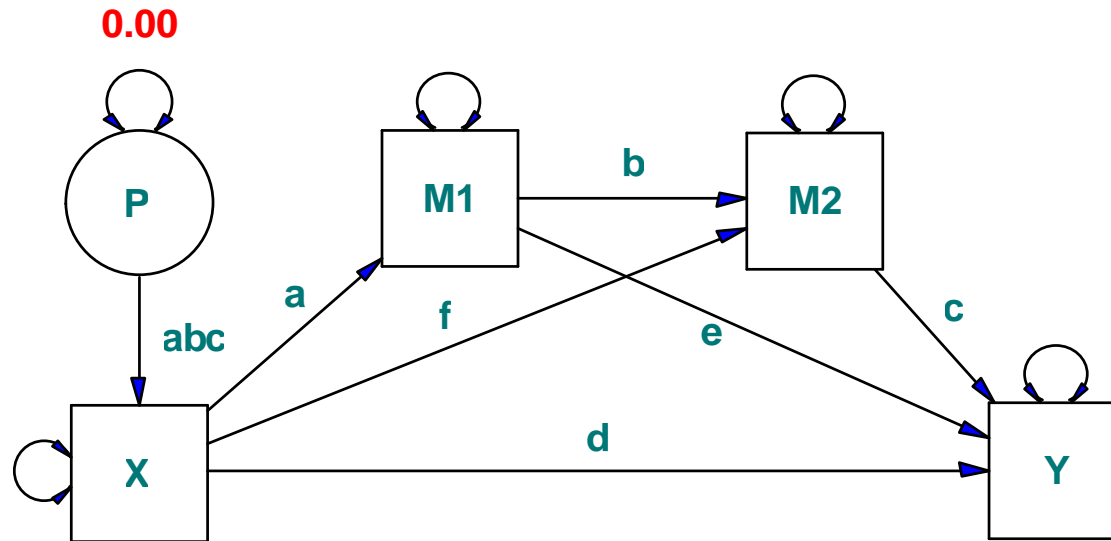
Intermediate mediators



- u One mediator may not be sufficient to explain the psychological process. For example, Premack and Hunter (1988) proposed 4 intermediate moderators to explain the process from wage levels to union votes.
- u The indirect effect = abc
- u However, it is not trivial to estimate the SE and CI on it.



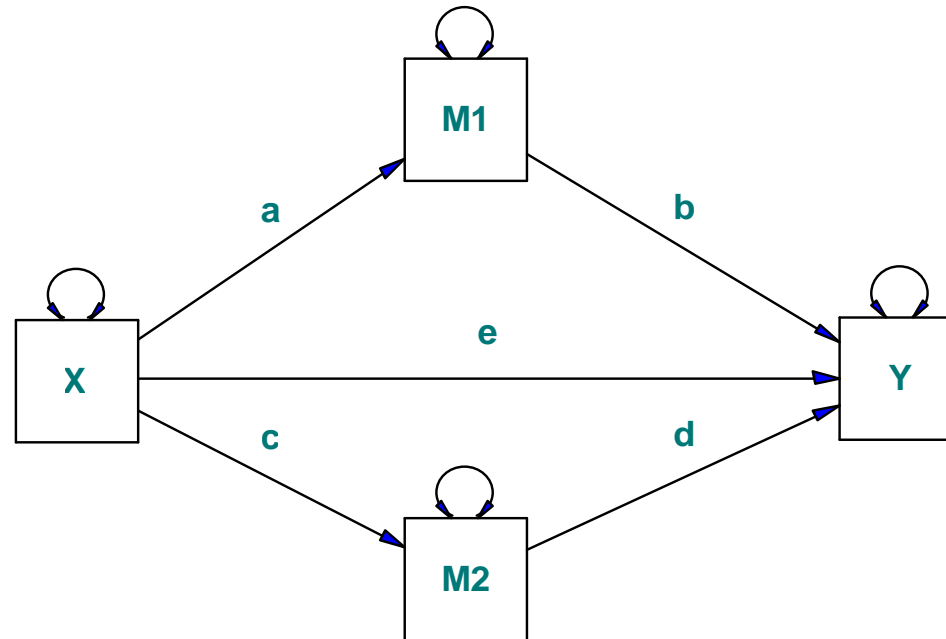
An SEM approach



- u We fix the **path=abc**
- u *SE* and *CI* on the path **are** the *SE* and *CI* on the indirect effect



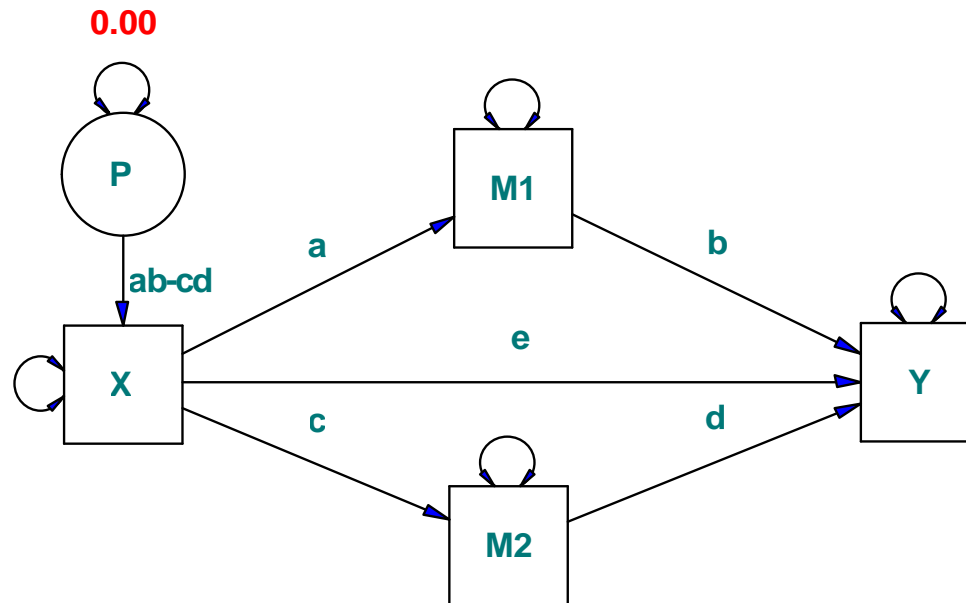
Specific mediators



- u Aryee et al., (2002) tested a model with trust in an organization ($M1$) and trust in a supervisor ($M2$) in explaining the effects from organizational justice (X) to work outcomes (Y)
- u To see which mediating effect is stronger, we compute $ab - cd$.



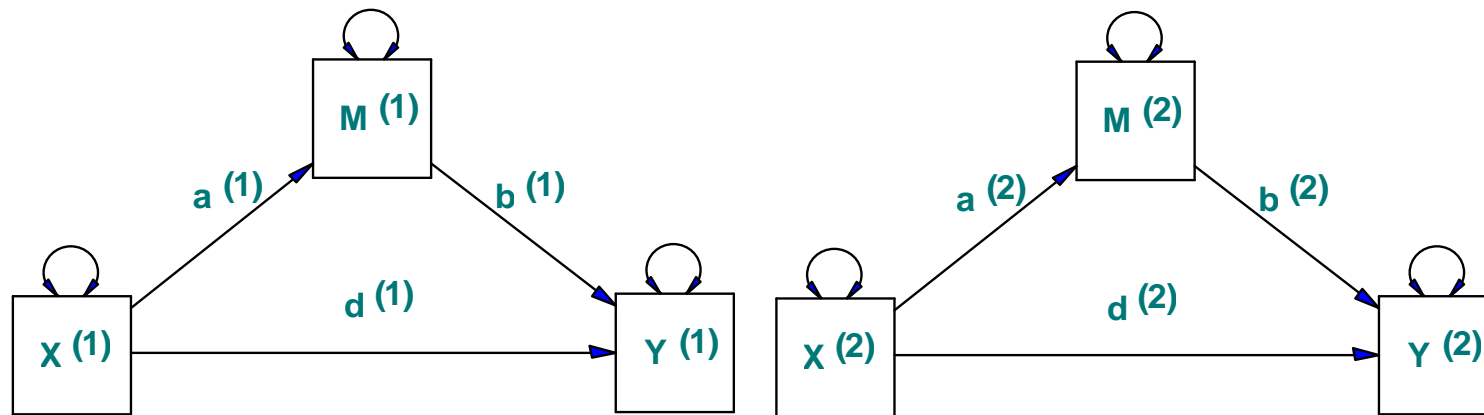
An SEM approach



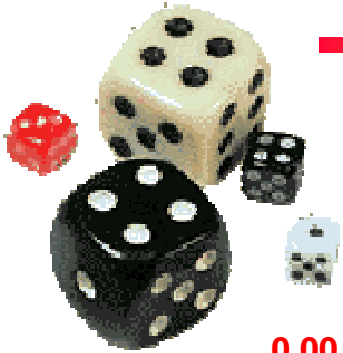
- u We fix the **path = $ab-cd$**
- u *SE* and *CI* on the path **are** the *SE* and *CI* on the difference of the indirect effects



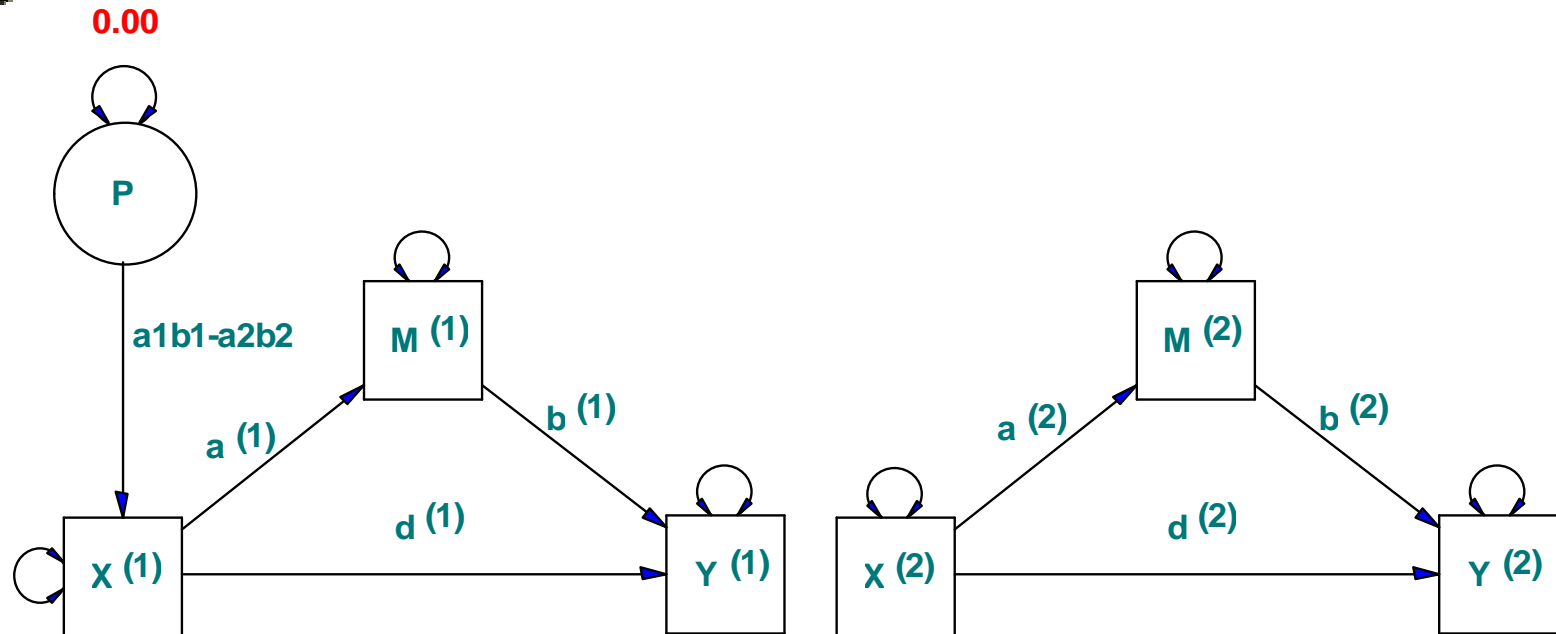
A moderated mediation



- u We may also be interested in comparing the indirect effects in two independent groups
- u To compare the moderated mediation, we may estimate $a^{(1)}b^{(1)} - a^{(2)}b^{(2)}$



An SEM approach



- u We fix the **path** = $a^{(1)}b^{(1)} - a^{(2)}b^{(2)}$
- u *SE* and *CI* on the path **are** the *SE* and *CI* on the difference of the indirect effects



Simulation studies

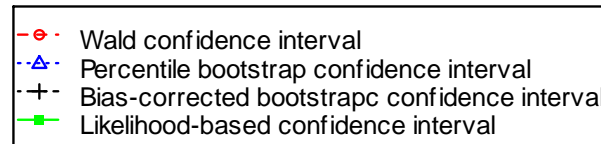
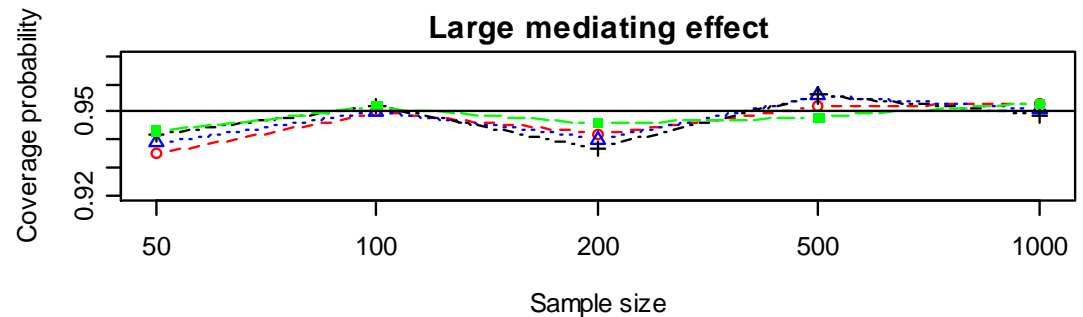
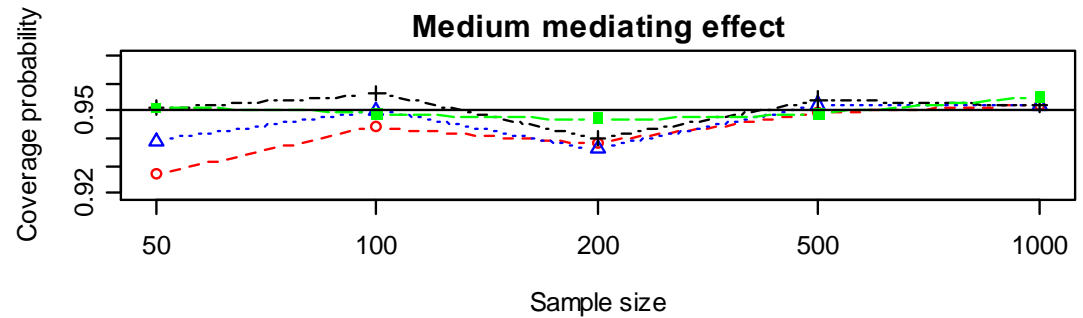
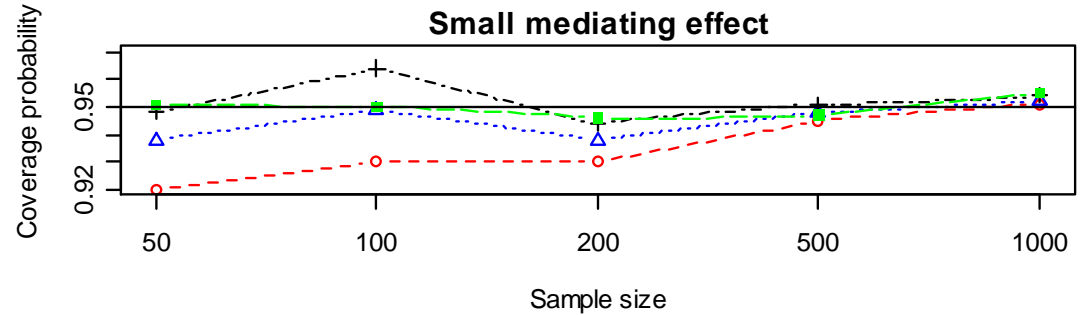
- u Four Monte Carlo simulation studies were conducted to compare the coverage probability of four CIs.
- u CIs compared:
 - Wald CI (based on SE)
 - Percentile bootstrap CI
 - Bias-corrected bootstrap CI
 - Likelihood-based CI
- u Studies:
 - Study 1: One mediator
 - Study 2: Two intermediate mediators
 - Study 3: Two specific mediators
 - Study 4: One moderated mediator



One mediator:

Wald CI is too liberal
except when the sample
sizes are large or the
effect size is large

Likelihood-based CI has
the best coverage
probability

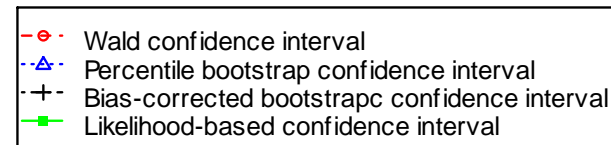
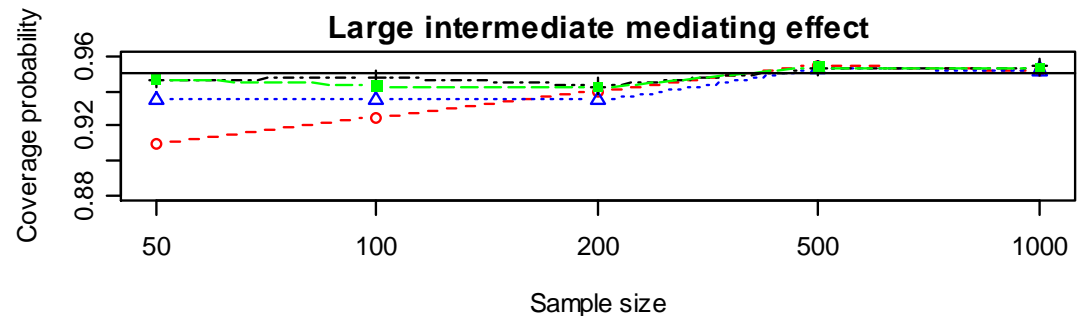
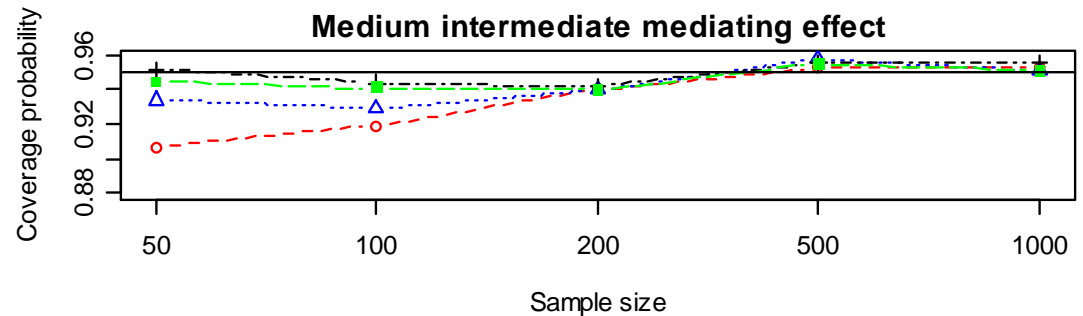
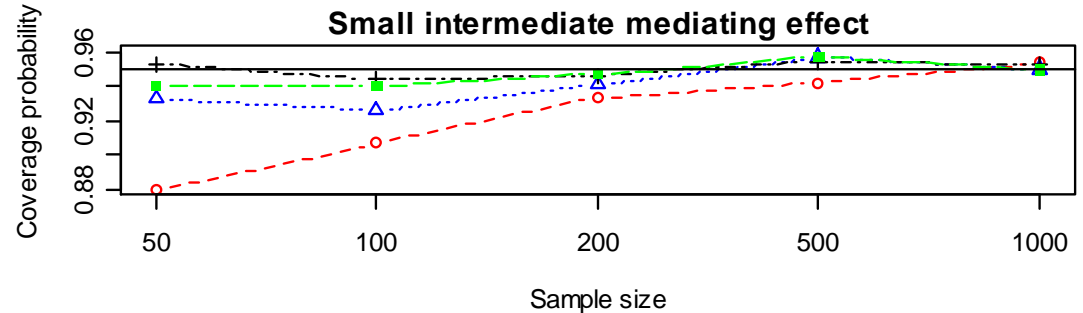




Two intermediate moderators:

Wald CI has the poorest performance again, especially when the sample sizes are small ($N=50$ or 100)

Other methods are comparable

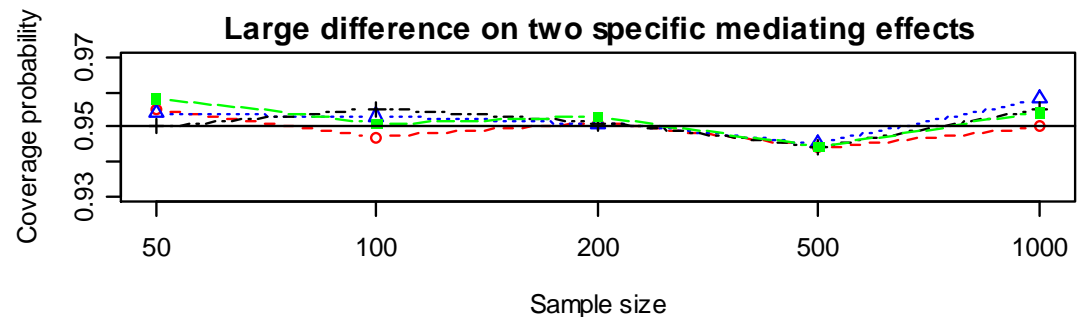
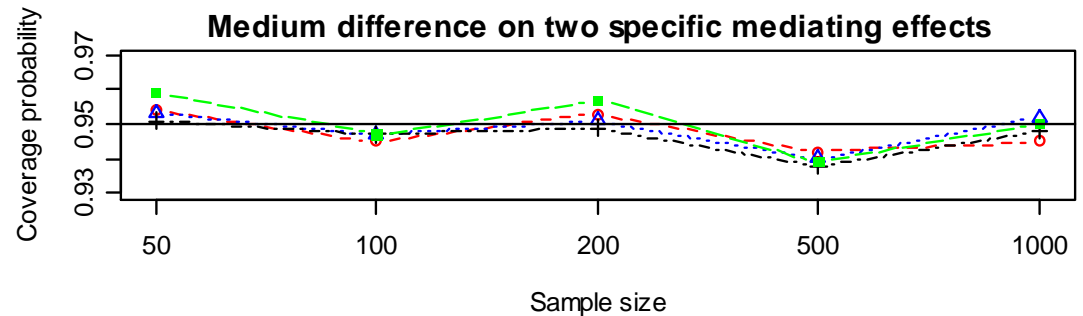
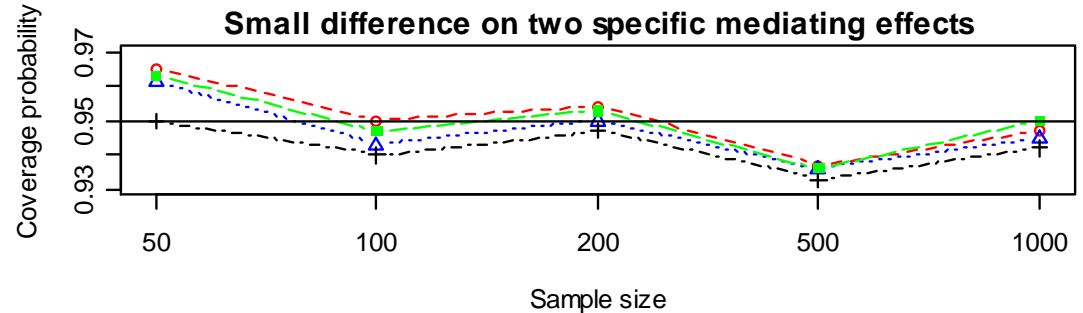




Two specific mediators:

Most are good except when the difference on the specific mediating effects is small.

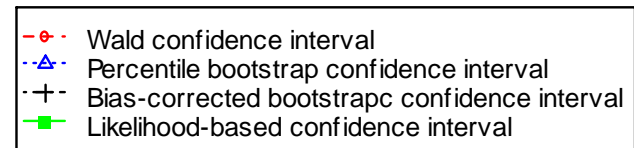
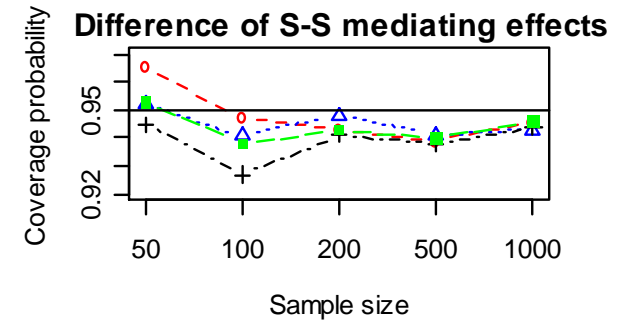
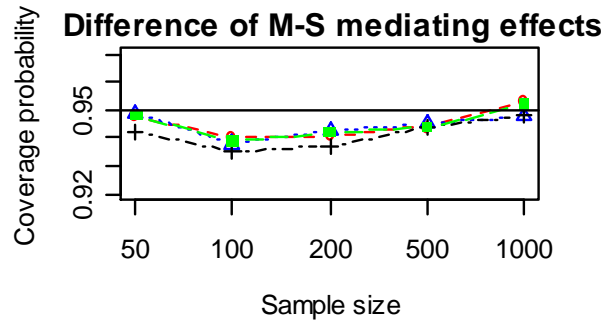
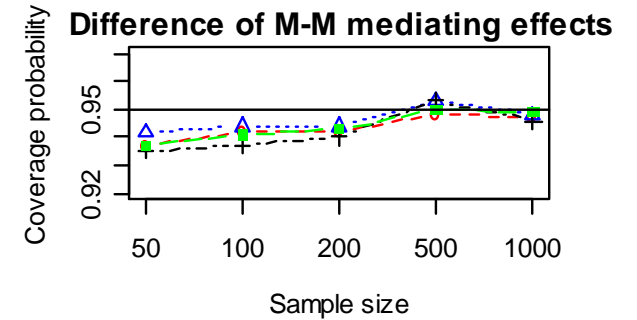
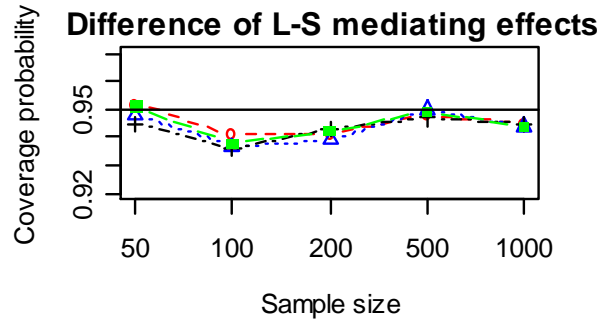
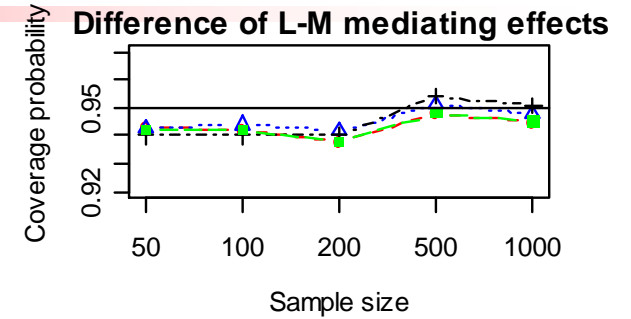
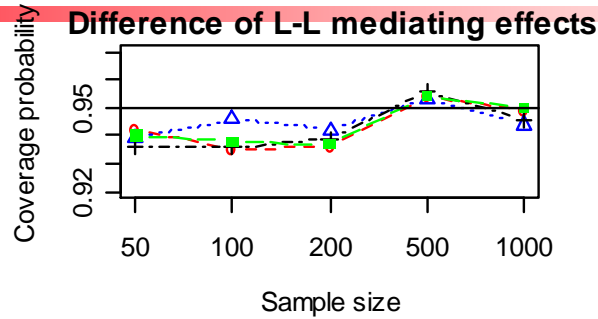
Bias-corrected bootstrap CI has the best coverage probability while others are too conservative in small sample sizes.



- o- Wald confidence interval
- △- Percentile bootstrap confidence interval
- +- Bias-corrected bootstrap confidence interval
- Likelihood-based confidence interval



u Moderated mediator:
 u Most methods are good except in the condition of S-S.





Conclusions

- u Based on the findings, Wald CI is not optimal. It is better to use other CIs.

- u SEM should be used to analyze mediating models:
 - Many mediating models can be easily specified in SEM
 - *SE* and CI can be easily obtained with the use of phantom variables
 - Wald CI, bootstrap CI and likelihood-based CI are available in many SEM packages